Laboratory

Half-wave rectifier with capacitive filter
Strumentation

Breadboard
Strumentation

Source
Strumentation

Oscilloscope
Half-wave rectifier with capacitive filter

- Let us consider a half-wave rectifier with a capacitive load, used to produce a steadier output

\[ t_1 < t < t_2 \]

When \( v_i > V_{ON} \), the diode is ON and the current flows toward R and C. C is charging with a low

\[ v_o = v_i - V_{ON} \]

\[ t_2 < t < t_3 \]

The diode turns OFF and the capacitance discharge with law

\[ v_o = \left( V_m - V_{ON} \right) e^{-\frac{t}{RC}} \]
Output Voltage

Assuming an high time constant $RC \gg T$ (period), then the exponential behaviour can be approximated with the tangent

$$V_{P} = V_{P} \cdot e^{-\frac{t}{RC}} \approx V_{P} \left(1 - \frac{t}{RC}\right)$$

In the time interval $t_{2} - t_{3}$, we can write

Assuming $t_{2} - t_{3} \approx T$, we can write

$$\Delta V = V_{P} - V_{P} \left(1 - \frac{T}{RC}\right) = V_{P} \cdot \frac{T}{RC}$$

From which

$$RIPPLE = \frac{\Delta V}{V_{P}} = \frac{T}{RC}$$
Currents in the diode

\[ i_D(t) = i_C(t) + i_R(t) = C \frac{dv_B(t)}{dt} + \frac{v_B(t)}{R} \]

\( t_1 < t < t_2 \rightarrow \) Diode ON

\( t_2 < t < t_3 \rightarrow \) Diode OFF

The maximum current occurs at the circuit start up, when the capacitor C is discharged.

\[ I_{D,\text{MAX}} = C \frac{dv_B(t)}{dt} \bigg|_{t=0} = C \frac{d}{dt} \left[ V_p \cdot \sin(\omega t) \right] \bigg|_{t=0} = 2\pi f \cdot C \cdot V_p \]
Synthesis relationships

Dimensioning of RC to control the Ripple

\[ \Delta V = \frac{V_p \cdot T}{RC} \]

RIPPLE = \[\frac{T}{RC}\]

Dimensioning of C to reduce the maximum current in the diode

\[ I_{D,MAX} \approx 2\pi f \cdot C \cdot V_p \]
Experience

Setup
Mount the circuit and apply a voltage signal \( V_{pp} = 10V \) and \( f = 1\text{kHz} \)

![Diagram of a circuit with a diode D1N4001, resistor R, and capacitor C, labeled A to B]

Work
- Determine the values for \( R \) and \( C \) in order to assure in B a Ripple < 10% of maxximum output voltage

<table>
<thead>
<tr>
<th>Datasheet</th>
<th>Conducting voltage</th>
<th>( V_y = 0.65V )</th>
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<tbody>
<tr>
<td>Diode 1N4001</td>
<td>Max current</td>
<td>( I_{max} = 30A )</td>
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